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Corrosion Management of the Italian Air Force Fleet

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ABSTRACT

Economic, safety and logistic issues are strongly affected by military aircraft corrosion, more when it regards an aging fleet[1-3].
Italian Air Force manages this matter by a Corrosion Control Register Program (CCR), a flexible and integrated support for making decisions both on prevention and operational measures.
The Program was born in 1994 as a necessary instrument to enhance partnership, in Tornado maintenance[4], with the German and the Royal Air Forces, but was immediately extended to six more aircraft (AM-X, MB.339, C-130, F.104, G.222, and Br.1150) and to two helicopters fleets (HH-3F and AB.212).
Some results of the activity carried out along these years, expressed in terms of useful information for the decision-makers, are shown.

Keywords: Corrosion Control Register Program, CCR, Italian Air Force, aging aircraft, Tornado.

1. INTRODUCTION

For too many years aircraft corrosion has been considered just as a technical matter that could be solved by means of a "found and fix" policy, while not enough attention has been given to the economic and safety factors related with it.
Nowadays, the need experienced all over the world to manage an ever more aged fleet gave back to corrosion a new interest, because of its strong connection with the increasing maintenance cost on one side and the difficulties in understanding the actual residual mechanical properties of a corroded part on the other.
This is the case of the Italian Air Force, that for a long time had not conceived any specific program about corrosion control except for a uniform training program for people working in maintenance, started in the eighties, and organized in two different levels depending on responsibility.
When, in 1994, Italian Air Force had to create the Corrosion Control Register in order to manage the Tornado maintenance in agreement with German and Royal Air Forces procedures, this instrument was made as flexible as possible in order to be extended to many more fleets. The Italian Corrosion Control Register Program (CCR) was started at the same time for six more aircraft and two helicopters fleets: since then a corrosion data bank managed at the Chemistry Department of Italian Air Force is updated each time corrosion is found at any step of the maintenance inspection carried out by the Air Force.
This Program doesn't cover the maintenance performed by any depot outer the Air Force.

2. BACKGROUND

The aim of the data collection is to produce a detailed picture of the IAF corrosion situation that once a year is discussed with all the depot maintenance center and provided to the Logistic Command to enhance the knowledge on the state of the fleet, where special attention is focused on the aging phenomena, and their effective needs.

Paper presented at the RTO AVT Specialists' Meeting on "Life Management Techniques for Ageing Air Vehicles", held in Manchester, United Kingdom, 8-11 October 2001, and published in RTO-MP-079(II).

Because of the high level of interdisciplinary which is characteristic for corrosion science and engineering, the Corrosion Control Register Program overlaps with many different fields first of all with NDE, helping in creating and developing new and more dedicated inspection procedures as far as new inspection techniques. In this sense for example, the use of a monitoring system based on electrochemical corrosion sensors, when located on previously investigated areas already detected as prone to suffer corrosion problems, seems a very promising integrated system to promote an early detection and, as a consequence of this, to enhance an effective corrosion protection and control[5].

The CCR Program actually moves from the report of every detected corrosion to the data bank by means of a standard procedure: the corrosion specialists must fill in a double sheet form divided in different sections where they report much useful information.

The data requested include:

- information about the aircraft (total flight hours, flight hours since last inspection, the base of operations where corrosion is found and the base where the aircraft more often stood in the past six months;
- information about the corroded part (name, Identification Code, Part Number, Serial Number, Work Unit Code, superior unit and its Part Number, etc..);
- information about the type of corrosion, using a classification code arranged by Italian Air Force to simplify the description and consequently to minimize false messages;
- schematic information about the maintenance operation carried out and its cost.
- a map of the corroded area (mandatory just for the parts where corrosion is already expected).

Corrosion classification, as said, was simplified by dividing corrosion distribution into only three different groups: general corrosion, selective corrosion and localized corrosion[6]. To each corrosion distribution some morphological aspects was then univocally linked.

2. RESULTS

Up to last year more than 2600 corrosions were recorded and much information was acquired. The most important of them can be summarized in:

a) Fleet corroding index

It has been calculated as an average on the last five years of the ratio *"corrosion per year"/"number of aircraft constituting the fleet"*. As expected, corrosion must be considered much more problematic for some fleets (fig. 1), in particular for the anti-submarine Br.1150, the cargo aircraft C.130 and helicopters used in Search and Rescue operations as AB.212.

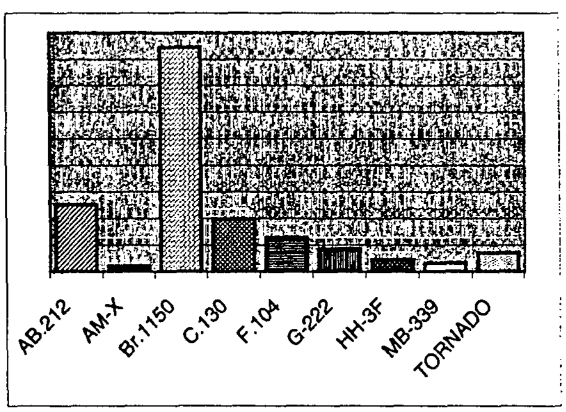

FIGURE 1 – FLEET CORRODING INDEX

This basic information doesn't take into account the differences in danger among the different types of corrosion neither the importance of the affected parts; nevertheless in a glance it gives a useful idea when, in occasion of immediate needs to fix priorities, will be reasonable to spend money and people in prevention first of all to face problems related to these fleets.

b) Index of fleet detectable corrosion

It has been calculated as an average of the last five years of the ratio *"corrosion per year"/"number of aircraft inspected in the Air Force"*. The information given in Figure 2 shows more details about the present engagement addressed to corrosion for the different fleets.

In fact, in the case of a perfect balance of the available resources, this graph should be superimposed on figure 1. In case of some discrepancy, assuming that the information about corrosion maintenance had correctly flown, it means it is necessary to adjust something, primarily in maintenance scheduling or in maintenance people training program, because too much or too little attention has been given to some or some other fleet.

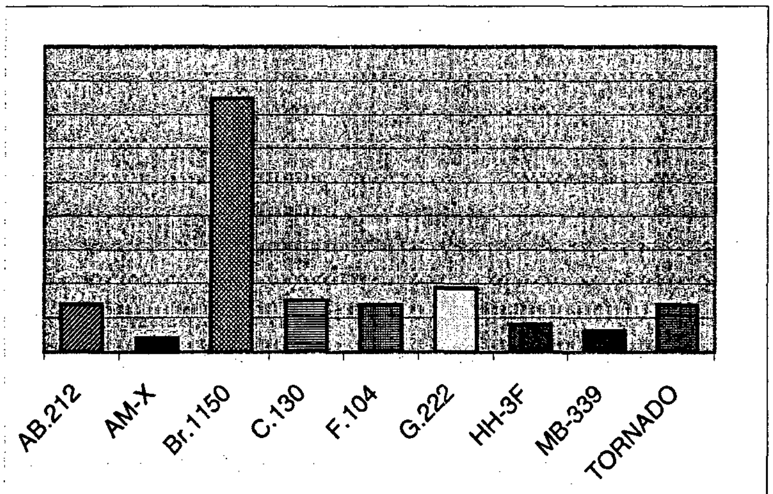

FIGURE 2 – INDEX OF FLEET DETECTABLE CORROSION

c) Corrosion detection reliability of the low inspection levels

In the IAF maintenance is generally conceived on three different levels the first two being devoted to the bases where aircraft operate. As the only difference is in the scheduled maintenance operations to carry out but not in the staff and its skill, here any difference will be considered between them.
The highest maintenance level is a depot inspection devoted to a Squadron operating for the entire fleet.
Previous GAF experiences of in-service corrosion on military aircrafts[7], pointed out the corrosion detectability before paint removal compared with corrosion detected after it: on average approximately 60% was considered as a typical value. As paint removal and components take down occurs only during the depot inspections, this value was also regarded as a reference term at the beginning of our data collection.
The model to be used, if we want to take into account that during the minor inspections corrosion can't ever be completely detected and considering a linear relationship between time and corrosion development, is that reported in Fig. 3. In this case I, II and III are three different scheduled minor inspections carried out by the *i* base, where each one allowed to detect the corrosions developed in the period of time elapsed between two inspections; IV is the major scheduled maintenance where more corrosions were found on the inspected aircraft proceeding from the same *i*-base.

In accordance with this model the corrosion detection reliability of the low inspection levels compared with the major one will be given by the following expression:

$$\frac{\dfrac{c_i}{n_i^{\,min.\,insp.}}}{\dfrac{c_i + C_i^{\,maj.\,insp.}}{n_i^{\,min.\,insp} + N_i^{\,maj.\,insp.}}} \cdot 100$$

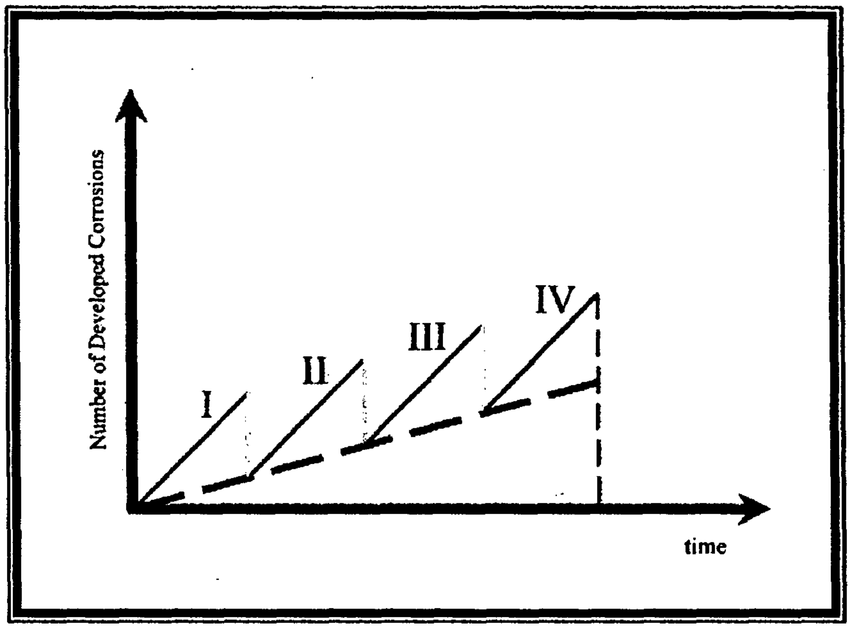

FIGURE 3 – SCHEME FOR CORROSION DETECTION RELIABILITY

By summing all the *i*-index maintenance results, the average on the corrosion detection reliability for the minor inspection levels will be obtained.

Of course such analysis needs a statistical significance of collected data, but previous results obtained on different fleets having very different mission profiles from each other give, for now, approximately the same average values.

If we consider for example the corrosion data acquired up to last year for the helicopter Agusta AB.212, an 80.6% corrosion maintenance detectability during the minor inspections was calculated on the 474 data collected (see Fig. 4).

The average value must be obviously considered as the most reliable, but the statistical analysis carried out until now already gives some reliable results for some bases (the colored ones); in some other cases (the white values) the data, themselves, have not yet a statistical significance because few helicopters proceeding from these bases have gone through the major inspection. Of course for the bases whose results are considered reliable (it means just on the colored ones) their maintenance work can be evaluate: in this real case we can positively judge the inspections carried out in this last three years at the bases *e, g, h* and *i* while big problems appear on the maintenance carried out at the base *f*.

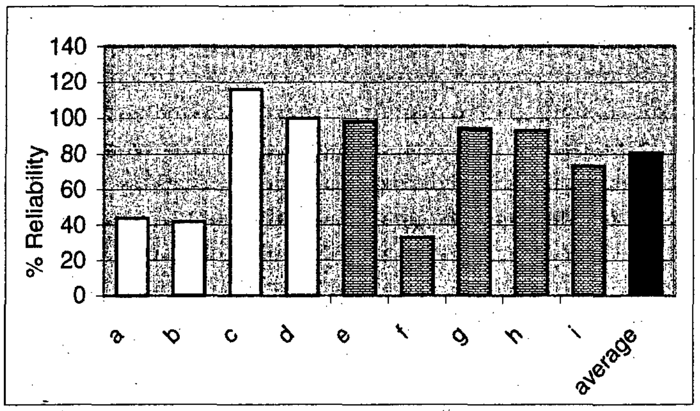

FIGURE 4 – CORROSION DETECTION RELIABILITY OF THE LOW INSPECTION LEVELS

For the anti-submarine Br-1150 operating in only two Italian bases, of which one is also the depot maintenance center, a similar result has been obtained: the corrosion detection reliability during the minor inspections, calculated on 555 data, was 70% in comparison to the corrosion found at the major ones.

d) Corrosion index distribution for each Squadron

This information allows us to understand the contribution of environmental and operative factors on corrosion. More frequently it is an environmental effect that has been observed, concentrated on those bases operating on the sea especially in the south, where high chloride content, high temperature and humidity are often combined.

e) Corrosion index for different parts

It has been considered for every fleet in order to evaluate for each one those items more often and more easily corroded. As the Program is working on very different aircraft they can be divided into the following categories:

- for cargoes, the majority of corrosion occurs on the wings and secondarily on the taileron and the fin;
- for helicopters, the most susceptible items are the honeycomb structures on the floor, followed by the main rotor and the blades;
- for fighters, corrosion is most often located on the body fuselage, the fuel cells, the air intakes and the landing gear;
- for anti-submarines corrosion is very spread, especially on the wings and on the bomb compartment.

f) Corrosion index as a function of aircraft flight hours

In the past, corrosion maintenance was scheduled in accordance with prescriptions fixed at the beginning of the aircraft life. Unfortunately many factors, among them the most important being time and usage, will make each aircraft increasingly unique[8]. To be proactive it needs to be able to understand the differences promoted by the age and in this sense this index allows us to monitor the corrosion susceptibility depending on the usage of the fleet and, consequently, to modulate the maintenance to aging.
This decision is demanded to the Logistics Command that is the organization responsible both for the fleet efficiency and for the way to spent the available resources to achieve it.

g) Maintenance procedures and costs for the different fleets

This kind of information is fundamental to address the maintenance policy, because it is the most direct instrument to know what is really happening with corrosion costs.
In effect, the economic parameter not only affects directly readiness and efficiency of the fleets but is also the starting point to balance any risk assessment.

At the moment is only showing the direct costs, the most important of them being the man hours spent, but it will be probably extended in the next future to much more elements.

h) Classification of corrosion danger for the different fleets

Safety can be certainly enhanced when damage danger, strictly related to damage tolerance, is known. In this sense, corrosion classification has been very useful in detecting the produced damage danger.
In fact, not every observed corrosion must be considered on the same danger level and particular attention must be paid to those selective attacks or some specific localized corrosion detected on principal items.
Four classes have been individuated (the most dangerous being the class 1) and the overall percentage of them is shown in figure 5. Such information must be considered as a powerful quantitative analysis instrument to fix the objective of an enhancement in corrosion prevention in control, because gives the opportunity to easily evaluate the effectiveness of any change produced in the medium-long term on the corrosion maintenance inspection and maintenance procedures which should be accomplished with a reduction in the class 1 phenomena.

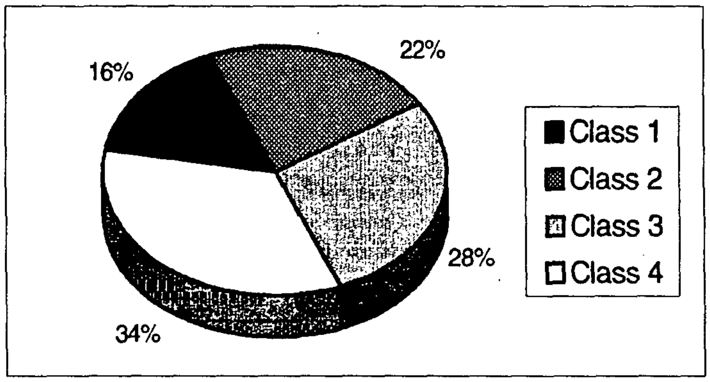

FIGURE 5 – PERCENTAGE OF CORROSION DANGER

When this information is split in the different fleets it is possible to evaluate for each one of them the risk factor associated with corrosion phenomena.

4. CONCLUSIONS

The Corrosion Control Program moved six years ago from a standardization of the training of people working in maintenance and it was originally born in order to manage the Tornado maintenance in agreement with the German and Royal Air Forces.

Actually, the Italian Air Force Corrosion Management can be summarized as a multitasking strategy where a specific engagement consists in the evaluation of the relationships occurring between corrosion and residual strength of aged structures.
Since it was running the Program has shown to be powerful in understanding problems and offering solutions in many different areas. Some of the most important information acquired up to now has been discussed as far as some actions already taken on this base.

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